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TOTAL NUMBER OF PAGES, INCLUDING COVER PAGE: 14

DATE : January 7, 2004 **TIME:**

CLIENT/DOCKET : 0796/65739 (Serial No. 09/931,511)

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In the matter of Swiss patent application 1644/00 of August 23, 2000

I, Dr. Kurt Sutter

of Holzweidstrasse 9, 8340 Hinwil, Switzerland,

do hereby declare that I am conversant with the English and German languages and am a competent translator thereof and certify that the following is a true translation made by me of the Swiss patent application identified above.

December 24, 2003
Date

Dr. Kurt Sutter

Flow sensor with a housing

The invention relates to a flow sensor according to the preamble of claim 1.

A known flow sensor of this type comprises a two part housing forming a measuring conduit. A semiconductor chip with a sensor arrangement is arranged at the wall of the measuring conduit. For sealing, the semiconductor chip is clamped between the housing sections.

This known solution has, however, the disadvantage that it is not suited for applications where there is a high static or dynamic pressure in the measuring conduit.

Hence, it is an object to provide a flow sensor with a housing that, if necessary, is able to withstand high pressure in the measuring conduit and that is built-up in simple manner.

This object is achieved by the flow sensor of claim 1.

Hence, according to the invention, a sealing ring surrounding the measuring conduit and the semiconductor chip is provided between the two housing sections. For connecting the semiconductor chip with the surroundings, a foil with conductors is pressed against by the sealing ring and led to the outside. In such an arrangement, substantially the full pressure drop is over the sealing ring where it can be absorbed well. The semiconductor chip does not have to take over any sealing function.

Preferably, the measuring conduit is formed by a groove in the surface of a first housing section. For connecting the groove with the surroundings, connecting ducts can be provided, e.g. in the form of bores or holes, which extend through one or both of the housing sections. The sealing ring can be arranged at said surface around the groove. This arrangement allows to seal the measuring conduit from all sides.

Preferably, the semiconductor chip is arranged in a recess of the second housing section and its top surface (i.e. the side with the sensor) is flush with the wall of the

measuring conduit such that there are as laminar flow conditions as possible. For exactly positioning the top surface of the semiconductor chip, the same is touching the first housing section. Preferably, a spacer is provided at the bottom of the recess, which spacer is deformed elastically or plastically by the pressure force of the housing sections and pushes the semiconductor chip against the first housing section such that an accurate and durable alignment of the semiconductor chip with the measuring conduit results when assembling the housing sections. The spacer can e.g. be formed by bumps at the bottom of the recess.

The flow sensor according to the invention is suited for measuring the flow of liquids or gases at normal or elevated pressure.

Other preferred embodiments and advantages result from the dependent claims as well as the now following description of a preferred embodiment by reference to the figures, wherein

Fig. 1 is an exploded view of a preferred embodiment of the flow sensor,

Fig. 2 shows the first housing section as seen from the second housing section,

Fig. 3 shows the second housing section as seen from the first housing section,

Fig. 4 shows a sectional view transversely to the measuring conduit through the flow sensor in the region of the semiconductor chip, and

Fig. 5 is a partial section of a possible embodiment of the semiconductor chip.

The flow sensor shown in the figures comprises a first housing section 1, a second housing section 2 and a semiconductor chip 3 substantially clamped between the housing sections 1, 2. Fig. 1 shows these parts at a distance from each other. In operation, however, the housing sections 1, 2 lie on top of each other and semiconductor chip 3 is clamped between them.

A straight groove 5 is arranged in a surface 4 of first housing section 1, which forms, together with adjacent

second housing section 2, a measuring conduit. Two connecting ducts 6 extend though second housing section 2, in the form of bores or openings, which connect the ends 5a, 5b of the measuring conduit to the environment. At the outer side of second housing section 2 the mouths of the connecting ducts 6 are surrounded by sealings 7 such that they can e.g. be connected to a tube to be measured.

A possible set-up of semiconductor chip 3 is shown in Fig. 5. It comprises a semiconductor substrate 10 with a sensor element integrated on its top side 11. It comprises, in conventional manner, a heater 12 between two temperature sensors 13a, 13b. The temperature sensors 13a, 13b are, when seen along the flow direction 14 of the medium to be measured, in front of and after heater 12, such that their temperature difference is a measure of the flow velocity or mass flow.

The sensor element is located on a membrane 15, which lies over an opening 16 extending through substrate 10.

As can in particular be seen from Figs. 3 and 4, semiconductor chip 3 is located in a recess 20 of the otherwise flat inner surface of second housing section 2, wherein the sensor element is facing the measuring conduit. It is connected to a flexible foil 9 carrying conductors and extending out of the flow sensor. For this purpose, a recess 22 is provided in the second housing section. Support foil 9 is e.g. a thin plastic carrier on which strip conductors are arranged. The total thickness of foil 9 is preferably less than 100 µm.

A nose 23 is arranged between recess 22 and groove 5 and rests against semiconductor chip 3. Four pyramidal bumps 21 are located as spacers at the bottom of recess 20. Second housing section 2 presses semiconductor chip 3 against the bumps 21, thereby slightly deforming the latter. This guarantees that semiconductor chip 3 is flush with the wall of the measuring conduit.

The bumps 21 are preferably an integral part of second housing section 2. They do not have to be pyramidal, but they should taper to a tip in undeformed state such that

the tips can be deformed by a small force. They can be deformed in elastic or plastic manner.

Recess 20 has two transversal sides 26a, 26b (Fig. 3) parallel to the measuring conduit and two longitudinal sides 27a, 27b perpendicular to the measuring conduit. At the ends of one of the transversal sides 26b recessed sections 28a, 28b are provided. Between the recessed sections 28a, 28b, transversal side 26b is straight and forms a well defined stop, which allows to position semiconductor chip 3 in exact manner perpendicularly to the measuring conduit. The recessed sections make sure that the semiconductor chip 3 does not abut against any rounded corners of the recess 20 that might have been caused by the production process.

Recess 20 is dimensioned such that some space remains between longitudinal sides 27a, 27b and semiconductor chip 20 such that the area between semiconductor chip 3 and the bottom of recess 20 is communicating with the measuring conduit. This ensures that both sides of membrane 15 (Fig. 5) are in contact with the measuring conduit, such that the pressure drop over membrane 15 is substantially zero, by means of which membrane 15 can be prevented from being damaged by high static or dynamic pressure.

As can be seen from Figs. 1, 2 and 4, a recess 30 in first housing section 1 having the shape of an elongate circle extends around groove 5. A sealing ring 31 is inserted into recess 30. When the sensor is assembled, sealing ring 31 is pressed against the inner side of second housing section 2, thereby sealing the measuring conduit to the outside in the region of the gap between the housing sections 1, 2.

Conductor foil 9 is led from semiconductor chip 3 between sealing ring 31 and the inner side of second hosing section 2. For better sealing, a sealant paste 32, such as silicone, can be arranged in the region of the crossing of foil 9 and sealing ring 31.

As can be seen from Fig. 2, semiconductor chip 3 is not arranged in the center of groove 5. Rather, it is located closer to exit end 5b than to entry end 5a of the measuring conduit. Since the medium to be measured flows from en-

try end 5a to exit end 5b, the asymmetric arrangement of semiconductor chip 3 closer to exit end 5b leads to a more laminar flow at the point of measurement.

The housing sections 1, 2 are preferably fabricated by injection moulding techniques. Then, sealing ring 31 is inserted into recess 30 and semiconductor chip 3 is inserted into recess 20. Now, sealing paste 32 can be applied at strip conductor 4. Then, the two housing sections 1, 2 are laid on top of each other and connected by means of screws inserted into screw holes 34.

The housing sections 1, 2 can be made from plastic and/or metal. In particular for high pressure, it is possible to fabricate the housing from an assembly of metal and plastic, the metal providing the required stability to the housing and the plastic being provided at the inner surfaces where good sealing and deformation properties are required. In particular, sealing ring 31 can also be a sealing rib made of a sealing material injection moulded directly into the housing sections.

In the present embodiment, the connecting ducts 6 are located in second housing section 2. One or both of them can, however, also be located in first housing section 1. On the other hand, sealing ring 31 could also be mounted in second housing section 2, or there could be a sealing ring in each of the housing sections 1 and 2.

The sensor described here can easily withstand a pressure of more than 25 bar if dimensioned properly. It can be used for flow measurements of any type in gases and liquids.

CLAIMS

1. A flow sensor with a housing with at least two housing sections (1, 2) between which a measuring conduit is formed, wherein, between the housing sections, a semiconductor chip (3) comprising a sensor element is arranged at a wall of the measuring conduit, characterized in that a sealing ring (31) surrounding said measuring duct and said semiconductor chip (3) is arranged between the two housing sections, wherein a foil (9) with conductors connected to the semiconductor chip is pressed against by the sealing ring (31) and is led to the outside.

2. The flow sensor of claim 1 characterized in that the measuring conduit is formed by a groove (5) in a surface (4) of at least one of the housing sections (1, 2), wherein the sealing ring (31) surrounds the groove (5), and that two connecting ducts end in the groove (5), wherein the connecting ducts (6) extend through at least one of the housing sections (1, 2).

3. The flow sensor of claim 2 characterized in that the sealing ring (31) is arranged at said surface (4), and in particular in a recess (30) in the surface (4).

4. The flow sensor of any of the preceding claims characterized in that the measuring conduit is formed by a groove (5) in a surface (4) of a first housing section (1), and that the semiconductor chip (3) is substantially flush with the wall of the measuring conduit and is arranged in a recess (20) of a second housing section (2) and is pressed against by the first housing section (1).

5. The flow sensor of claim 4 characterized in that between the semiconductor chip (3) and a bottom of the recess (20) at least one spacer (21) is arranged, wherein the spacer (21) is plastically and/or elastically

deformed by a pressure force exerted by said housing sections (1, 2) on each other.

6. The flow sensor of claim 5 characterized in that the spacer (21) comprises a plurality of bumps, preferably tapering to a tip in an undeformed state, on the bottom of the recess, and in particular that the bumps are an integral part of the second housing section (2).

7. The flow sensor of one of the claims 4 to 6 characterized in that the recess (20) comprises a transversal side (26b) parallel to the measuring conduit, which ends at its ends in recessed sections (28a, 28b), such that the transversal side (26a) forms a straight stop edge for positioning the semiconductor chip (3) perpendicularly to the measuring conduit.

8. The flow sensor of any of the preceding claims characterized in that the foil (9) with conductors is sealed at the sealing ring (31) by means of a sealant paste (32).

9. The flow sensor of any of the preceding claims characterized in that the semiconductor chip (3) comprises a membrane (15), on which the sensor element is arranged, wherein both sides of the membrane are in contact with the measuring conduit such that the pressure drop over it is substantially zero.

10. The flow sensor of any of the preceding claims characterized in that the semiconductor chip (3) is arranged closer to an exit end (5b) than to an entry end (5a) of the measuring conduit.

ABSTRACT

The flow sensor has a first and a second housing section (1, 2) between which a semiconductor chip (3) with a sensor element is arranged. The semiconductor chip (3) lies at a measuring conduit formed by a groove (5) in the first housing section (1). A sealing ring (31) is arranged between the housing sections (1, 2). The foil (9) with conductors is led to the outside between the sealing ring (31) and the second housing section. This simple arrangement is able to withstand high pressure.

(Fig. 1)

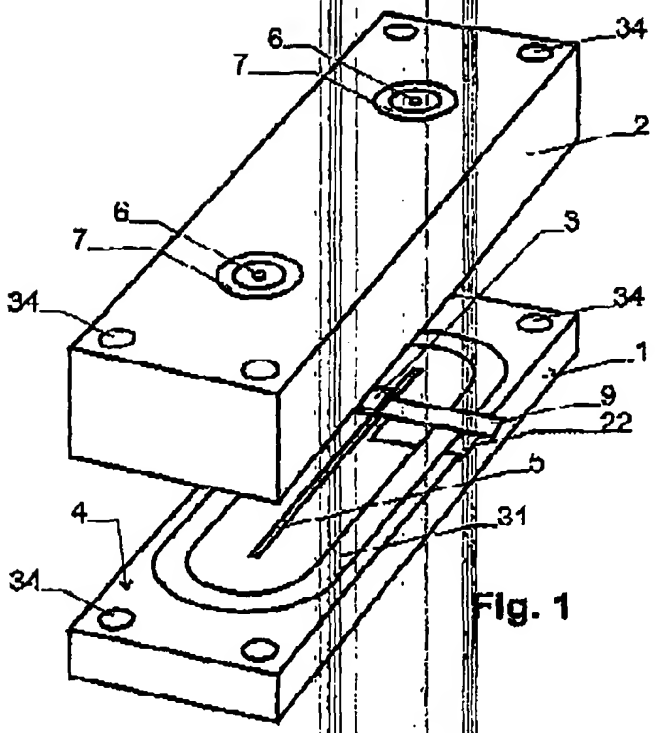

Fig. 1

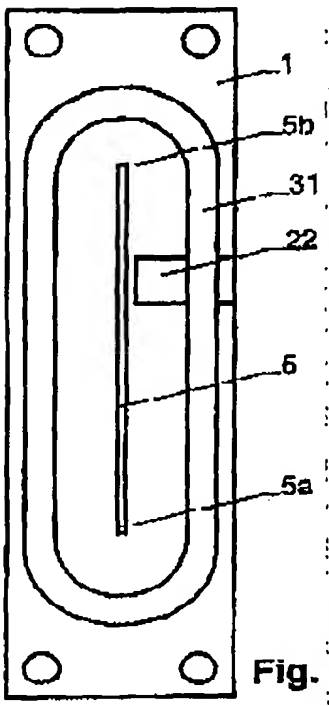

Fig. 2

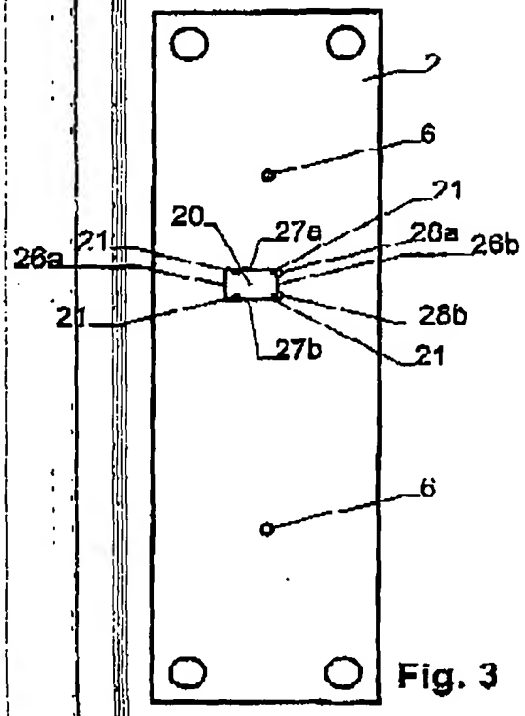

Fig. 3

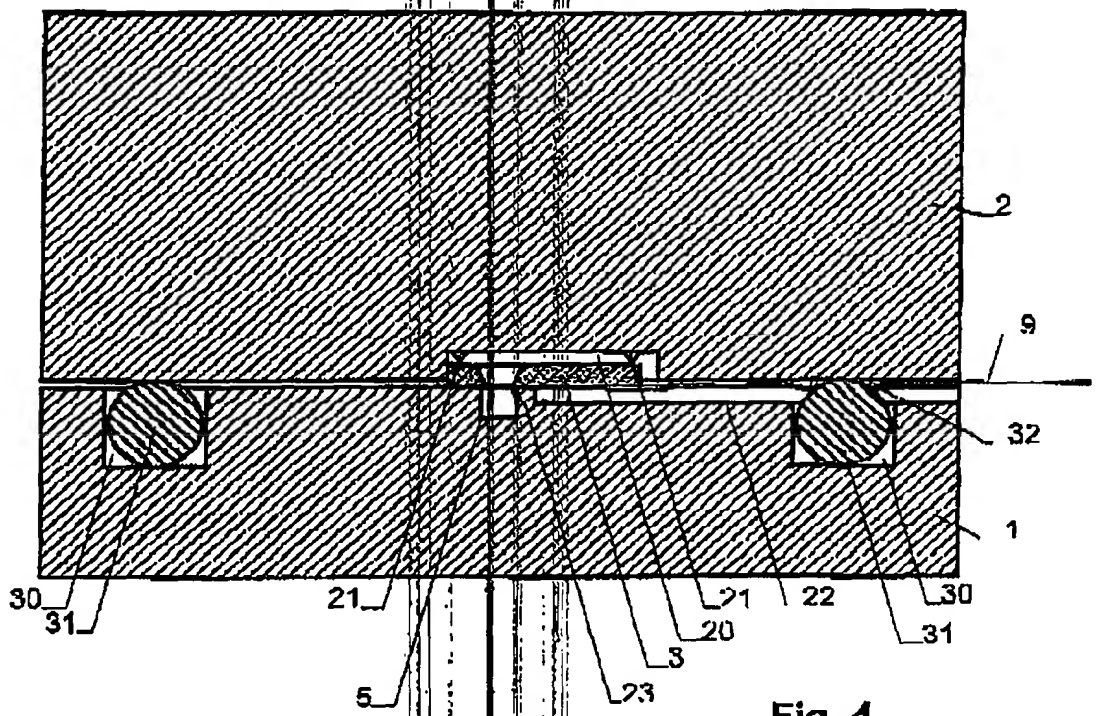

Fig. 4

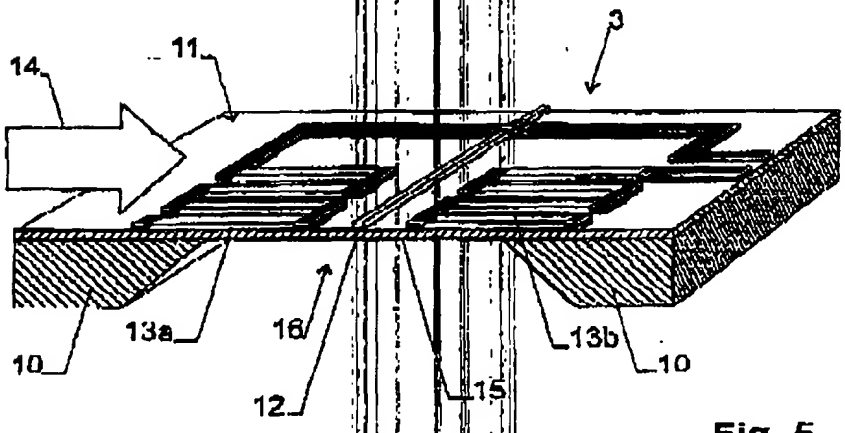

Fig. 5

PATENT
S.N. 09/931,511
0796/65739

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Felix Mayer and Mark R. Hornung
Serial No.	:	09/931,511
Filed	:	August 16, 2001
For	:	FLOW SENSOR IN A HOUSING
Group A.U.	:	2855
Examiner	:	Harshad R. Patel **Fax No.: 703-746-4416**

I hereby certify that this paper is being transmitted this date to fax No. 703-746-4416 (Non-Fee Amendment; Commissioner of Patents and Trademarks, P.O. Box 1450, Alexandria, VA 22313-1450).

Donald S. Dowden
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Date
January 7, 2004

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January 7, 2004

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Sir:

This follows the amendment mailed November 12, 2003.

PATENT
S.N. 09/931,511
0796/65739

We are transmitting herewith a Verified Translation of the Swiss priority document for the present application, namely No. CH 1644/00 of August 23, 2000. Since US Patent No. 6,591,674, of record, which we discussed with the Examiner by telephone following the filing of the above-referenced amendment, has an effective reference date that is later than the priority of the present application, the '674 patent is unavailable to support a rejection of the claims of the present application.

It is respectfully submitted that the application is in condition for allowance; issuance of a Notice of Allowance is respectfully solicited.

Respectfully submitted,
COOPER & DUNHAM LLP

Donald S. Dowden
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DSD:mg